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The Management of Anesthesia-Related Drug Shortages: A Systems-Level Crisis Response

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Abstract

Background: Anesthesia-related drug shortages pose a significant threat to global healthcare, impacting patient safety and surgical outcomes. Shortages of essential drugs, such as propofol and opioids, force clinicians to use unfamiliar alternatives and adjust protocols. These shortages result from complex supply chain issues, including manufacturing quality problems and material scarcities. **Aim:** This narrative review synthesizes evidence from 2010 to 2024 on interdisciplinary, systems-level strategies for mitigating the impact of anesthesia drug shortages. **Methods:** A comprehensive search of PubMed, Scopus, CINAHL, and regulatory agency databases was conducted. **Results:** Evidence indicates that effective management requires a tiered, team-based approach. Pharmacy must lead supply chain surveillance and develop evidence-based substitution protocols. Anesthesia must adapt clinical techniques, employing multi-modal analgesia and regional anesthesia to reduce reliance on scarce agents. Nursing is critical for patient monitoring, education, and ensuring continuity of adapted care plans. Successful institutional responses are characterized by centralized drug shortage committees, real-time communication, and simulation training for crisis scenarios. **Conclusion:** Anesthesia drug shortages are not transient disruptions but endemic features of modern healthcare. Mitigating their impact requires moving from ad-hoc, reactive responses to embedded, interdisciplinary preparedness plans that prioritize patient safety through shared stewardship, protocolized adaptation, and transparent communication across the perioperative team.

Keywords: drug shortages, anesthesia, supply chain management, patient safety, interdisciplinary teams

Introduction

The practice of modern anesthesia is built upon a reliable pharmacopeia: induction agents like propofol to render patients unconscious, opioids and inhaled anesthetics to blunt surgical stress, neuromuscular blocking agents (NMBAs) to facilitate intubation and surgery, and local anesthetics to provide regional analgesia (Ortmann et al., 2021). The availability of these drugs is so fundamental that their potential absence is scarcely contemplated in daily practice. Yet, over the past fifteen years, the global healthcare system has been plagued by recurrent, severe shortages of these very agents, exposing a critical vulnerability at the heart of surgical care (DiPiro et al., 2021; Woodcock & Wosinska, 2013). From nationwide deficits of propofol and fentanyl to critical shortages of local anesthetics like bupivacaine and lidocaine, these crises force anesthesiologists to use unfamiliar second-line drugs, alter well-honed protocols, and make difficult triage decisions about which cases proceed (Hsia et al., 2015; Tucker et al., 2020).

The causes of these shortages are multifactorial and systemic, rooted in a fragile global supply chain for sterile injectable drugs. Key drivers include: manufacturing quality issues leading to shutdowns of major production facilities; economic disincentives that cause manufacturers to abandon low-margin generic injectables; just-in-time inventory models that leave hospitals with minimal buffer stock; and regulatory complexities that slow the approval of new suppliers or alternative formulations (Mazer-Amirshahi et al., 2017; Ventola, 2011). The consequences are far-reaching. Clinician workload

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increases due to the cognitive burden of managing alternatives; patient safety is jeopardized by the use of less familiar drugs with different pharmacodynamic profiles; surgical case cancellations or delays escalate; and healthcare costs rise due to the procurement of expensive brand-name alternatives (Claus et al., 2015). These shortages represent a profound failure of market and regulatory mechanisms, placing the burden of crisis management squarely on frontline healthcare institutions and their clinical teams (Caulder et al., 2015). Figure 1 illustrates the interdisciplinary response to anesthesia-related drug shortages.

Figure 1. Systems-Level Framework for Managing Anesthesia Drug Shortages

This narrative review synthesizes the contemporary evidence (2010-2024) to argue that effective management of anesthesia drug shortages cannot be the sole responsibility of any single discipline. It is an inherently interdisciplinary systems challenge that demands a coordinated, pre-emptive response from three core pillars: Pharmacy, Anesthesia, and Nursing. Pharmacy serves as the institutional nerve center for supply chain intelligence, therapeutic substitution, and conservation policy. Anesthesia must function as the adaptive clinical engine, modifying techniques and priorities based on pharmacologic constraints. Nursing provides the essential continuity of vigilance and patient communication, ensuring safety and understanding at the bedside. The central thesis is that navigating a drug shortage is not merely a logistical exercise but a high-stakes test of clinical governance, requiring a shift from reactive scarcity management to proactive resiliency planning. This review will delineate the distinct and synergistic roles of each discipline, evaluate the evidence for effective institutional strategies, and propose a framework for building a resilient perioperative medication ecosystem.

The Pharmacy Command Center

The pharmacy department, particularly the sterile products and clinical pharmacy teams, is the logical epicenter for institutional shortage management. Their role spans from strategic forecasting to the granular details of vial preparation (Table 1).

Supply Chain Surveillance and Tiered Alert Systems

Proactive management begins with intelligence. Pharmacies must establish robust mechanisms for monitoring shortage alerts from sources such as the FDA Drug Shortages Database, the American Society of Health-System Pharmacists (ASHP) Center for Drug Shortages, and direct communications from wholesalers and group purchasing organizations (GPOs) (Romano et al., 2022). Upon confirmation of a current or impending shortage, the pharmacy should activate a tiered alert system. A Tier 1 (critical) shortage, such as for succinylcholine or epinephrine, requires immediate, hospital-wide communication and action. A Tier 2 (significant) shortage, like a specific concentration of bupivacaine, triggers department-level conservation protocols. This system prevents the chaotic, rumor-driven responses that can exacerbate panic and hoarding (Phuong et al., 2019).

Developing Evidence-Based Therapeutic Substitution Protocols

The most critical pharmacy-led intervention is the rapid development and dissemination of evidence-based substitution protocols (Shanthanna et al., 2020). These are not simple one-to-one drug swaps but comprehensive guidance documents created in close collaboration with anesthesiologists. For a propofol shortage, a protocol may outline alternative induction regimens using etomidate or ketamine, complete with dose equivalencies, contraindications, and monitoring considerations (Schraag et al., 2018). For an opioid shortage, it may provide a multimodal analgesia matrix, recommending increased use of regional blocks, NSAIDs, and non-opioid adjuncts like dexmedetomidine or lidocaine infusions (Verla & Iqbal, 2021). These protocols standardize practice during a crisis, reducing variation and cognitive load for clinicians.

Inventory Management and Conservation Strategies

The pharmacy implements tactical measures to extend existing supplies. This includes centralizing inventory to prevent hoarding in individual ORs or satellite pharmacies, implementing waste reduction initiatives (e.g., using smaller vials, optimizing multi-dose vial beyond-use dating where safe), and restricting use of the scarce agent to only approved indications (e.g., reserving a specific neuromuscular blocker for rapid sequence intubation only) (Vo et al., 2021). They may also oversee compounding of certain agents if active pharmaceutical ingredients remain available, though this is resource-intensive and raises sterility assurance concerns (Kay et al., 2018).

The Anesthesia Adaptive Response

Anesthesiologists must translate the pharmacy's constraints into safe clinical practice. This

requires flexibility, a deep knowledge of pharmacology, and clear communication within the surgical team.

Clinical Adaptation and Technique Switching

The core adaptive strategy is to reduce or eliminate dependence on the scarce drug. This often necessitates a return to older techniques or increased utilization of regional anesthesia (Arumugam et al., 2020). During a local anesthetic shortage, anesthesiologists may shift from single-injection peripheral nerve blocks to continuous catheter techniques to maximize the duration of analgesia from a limited volume, or increase their use of spinal and epidural anesthesia for suitable cases (Zhang et al., 2019). During a volatile anesthetic or propofol shortage, greater use of total intravenous anesthesia (TIVA) with alternative agents or spinal/epidural techniques for lower-body surgery becomes imperative. This requires not only individual skill but also efficient scheduling and block room management to accommodate longer setup times (Ho et al., 2019).

Prioritization and Triage

In severe shortages, difficult triage decisions become unavoidable. Anesthesia leadership, in consultation with surgery and hospital administration, must establish usage priority guidelines. These guidelines objectively define which patients or procedures have the strongest claim to the dwindling supply. For instance, remaining stocks of succinylcholine might be reserved exclusively for emergency airway management or for patients with a known difficult airway, while rocuronium is used for routine cases (Emanuel & Persad, 2023). Similarly, the last vials of a specific opioid might be allocated to major oncology or trauma surgeries. These decisions are ethically fraught and must be made transparently and prospectively to avoid ad-hoc bedside rationing.

Enhanced Monitoring and Pharmacovigilance

Using alternative agents introduces new risks. Anesthesiologists must heighten their vigilance for unfamiliar side effects or altered therapeutic windows. For example, switching from propofol to etomidate requires close monitoring for adrenal suppression in critically ill patients; using ketamine demands attention to emergence phenomena and hemodynamic effects (Schraag et al., 2018). This heightened monitoring mandate must be clearly communicated to the entire intraoperative and postoperative team.

The Nursing Safety Net: Bedside Vigilance, Education, and Continuity

The nursing role—encompassing preoperative, intraoperative (circulating nurse), and post-anesthesia care unit (PACU) nurses—is the critical linchpin for safe execution of adapted plans and patient-centered communication.

Patient and Family Education

Nurses are often the first and most trusted point of contact for patient concerns. During a shortage, they play a vital role in managing patient expectations. Preoperative nurses must be prepared to explain, in understandable terms, why an anesthetic plan may differ from what was previously discussed or expected (Gulbis et al., 2013). This includes educating patients about alternative medications, potential differences in side effect profiles (e.g., "You may feel more drowsy after surgery with this different medicine"), and reassuring them that safety remains the paramount concern (Kuruc Poje et al., 2021). Transparent, empathetic communication can alleviate anxiety and build trust during a period of system stress.

Vigilant Monitoring for Alternative Agent Effects

In the PACU and on postoperative floors, nurses are the primary detectors of adverse drug reactions. With protocol changes, they must be acutely aware of the signs associated with alternative agents (Valk & Struys, 2021). For instance, if ketamine is used more widely, nurses must monitor for hallucinations, nightmares, or hypertension. If etomidate is used, they should watch for signs of adrenal insufficiency in vulnerable populations (Malapero et al., 2017). This requires targeted, just-in-time education from pharmacy and anesthesia when new protocols are rolled out.

Ensuring Continuity of the Adapted Care Plan

Nurses ensure the modified anesthesia plan is consistently executed across the care continuum. The circulating nurse verifies the correct alternative medication is drawn up and labeled in the OR (Ghai et al., 2022). The PACU nurse receives a clear handoff about the agents used and the specific monitoring required. The floor nurse administers postoperative analgesic regimens that align with the intraoperative opioid-sparing strategy, understanding that breakthrough pain may be managed with non-opioid alternatives first (Gewandter et al., 2021). This continuity is essential for preventing errors and managing patient comfort effectively. Figure 2 maps the coordinated roles of pharmacy, anesthesia, and nursing across preoperative, intraoperative, and postoperative phases. The figure highlights substitution protocols, technique adaptation, patient education, and enhanced monitoring required when standard anesthetic agents are unavailable.

Table 1: Interdisciplinary Roles in Managing an Anesthesia Drug Shortage

Discipline	Core Functions & Strategies	Key Actions During a Crisis	Critical Interactions
Pharmacy	**Supply Chain Intelligence & Stewardship**	Monitors national alerts; Activates tiered shortage protocol; Develops evidence-	Provides real-time supply data to Anesthesia; Collaborates on protocol

		based substitution guidelines; Centralizes inventory & implements restrictions.	creation; Educates Nursing on new drug profiles.
Anesthesia	**Clinical Adaptation & Prioritization**	Modifies techniques to conserve/avoid scarce drug (e.g., regional, TIVA); Establishes triage guidelines for prioritized use; Heightens monitoring for alternative agents.	Works with Pharmacy on protocols; Communicates changes and rationales to surgical team & Nursing; Leads case prioritization discussions.
Nursing (Pre-op, OR, PACU, Floor)	**Patient Safety, Education & Continuity**	Educates patients/families on plan changes; Provides vigilant monitoring for effects of alternative drugs; Ensures consistent execution of adapted plan across all phases of care.	Receives education from Pharmacy/Anesthesia on new drugs; Communicates patient concerns/questions to the team; Provides crucial feedback on patient responses to alternatives.

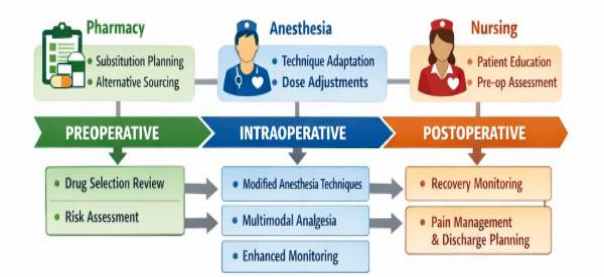

Figure 2. Interdisciplinary Roles Across the Perioperative Continuum During Drug Shortages

Synthesis of Evidence: Effective Systems-Level Responses

The literature points to several key features of institutions that successfully weather drug shortages.

The Centralized Drug Shortage Committee (DSC)

The most effective model is a standing, interdisciplinary DSC co-chaired by Pharmacy and Anesthesia, with representation from Nursing, Surgery, Risk Management, and Hospital Administration. This committee meets regularly to monitor the shortage landscape and is empowered to activate crisis protocols swiftly (Mazer-Amirshahi et al., 2017). It ensures decisions are collaborative, transparent, and aligned with institutional safety goals.

Simulation and Preparedness Training

Leading institutions conduct simulation exercises for shortage scenarios. These drills train teams to use alternative agents, practice new protocols, and identify workflow bottlenecks before a real crisis hits (Liu et al., 2021). They are particularly valuable for nursing staff in the PACU and ICU who will manage patients postoperatively under new regimens.

Transparent Communication Frameworks

A clear, multi-channel communication plan is non-negotiable. This includes timely email alerts, updates on the hospital intranet, dedicated line-item discussions in departmental meetings, and visual aids (e.g., posted algorithms in anesthesia workrooms and PACUs) (Abu Zwaida et al., 2022). Consistent messaging prevents confusion and ensures all team members are operating from the same information.

The outcomes of such structured approaches are measurable. They lead to reduced case cancellations, as alternatives are planned proactively; maintained or improved patient safety metrics, through standardized protocols and enhanced monitoring; and lowered stress and moral distress among clinicians, who feel supported by a clear institutional strategy rather than abandoned to individual crisis management (AlRuthia et al., 2017; Sinow et al., 2021).

Barriers, Ethical Considerations, and Future Directions

Implementing these interdisciplinary systems faces significant barriers (see Table 2). Siloed decision-making remains common, with pharmacy managing supply in isolation from clinical needs. Inadequate health information technology (HIT) support is a major hurdle; EHRs rarely have functionality to enforce drug shortage protocols, flag alternative agents, or communicate shortage status effectively at the point of order entry (Fox & McLaughlin, 2018). Economic pressures can conflict with stewardship, as cheaper, scarce generic agents are replaced by expensive brand-name drugs, straining hospital budgets.

Ethical dilemmas are pervasive. The process of triage and prioritization forces explicit rationing, challenging the principle of treating each patient based on individual need. There is also an ethical obligation for transparency with patients about how shortages may affect their care, a practice not yet standardized (Kong et al., 2020).

Table 2: Barriers and Enablers for Effective Shortage Management Systems

Domain	Critical Barriers	Essential Enablers & Solutions

Organizational & Cultural	Siloed departments making independent decisions; Lack of a standing, empowered oversight committee; Reactive vs. proactive institutional culture.	Establishment of a **multidisciplinary Drug Shortage Committee** with executive support; Creation of a formal, tiered **shortage response policy**; Leadership fostering a culture of **shared stewardship**.
Communication & Workflow	Inconsistent, delayed messaging to frontline staff; Lack of integrated EHR tools to guide prescribing during shortages; Cognitive overload for clinicians learning new protocols.	Development of a **standardized communication cascade** (email, intranet, huddles); **Integration of shortage alerts and protocols into the EHR** with hard stops or nudges; **Just-in-time training** and visual aids (cheat sheets) in clinical areas.
Economic & Regulatory	High cost of branded substitutes erodes conservation efforts; Just-in-time inventory models eliminate buffer stock; Complex regulatory pathways delay approval of new suppliers.	**Strategic buffer stocking** of critical, high-risk agents (where financially feasible); **Advocacy for policy changes** (e.g., manufacturing incentives, streamlined FDA review for shortage mitigation); **Contracting flexibility** with multiple suppliers.
Education & Training	Lack of clinician familiarity with second- and third-line agents; Inadequate training for nursing staff on monitoring new side effect profiles.	**Incorporating shortage management into simulation curricula**; **Regular in-service education** by pharmacy on alternative drug pharmacology; **Creating "playbooks"** for specific shortage scenarios (e.g., "Propofol Shortage Playbook").

Future directions must focus on systemic resilience. This includes advocating for national policy reforms to secure the generic injectables market, investing in predictive analytics to better forecast shortages, and designing smarter EHR systems that can dynamically support clinical decision-making during resource constraints.

Conclusion

Anesthesia-related drug shortages have evolved from intermittent disruptions to a chronic condition of modern healthcare delivery. They reveal the perilous dependence of advanced medical practice on brittle, economically motivated supply chains. As this review demonstrates, navigating these shortages successfully is impossible through individual heroism or departmental isolation. It demands a disciplined, systems-level response that leverages the unique expertise of pharmacy, anesthesia, and nursing in a unified framework.

The goal must shift from merely surviving the next shortage to designing a resilient perioperative medication system. This system is characterized by proactive intelligence, pre-vetted protocols, embedded interdisciplinary communication, and a culture of shared stewardship over finite resources. By institutionalizing these practices—through standing committees, simulation training, and integrated technology—healthcare organizations can transform drug shortages from paralyzing crises into managed challenges. In doing so, they uphold their fundamental duty to provide safe, effective, and equitable care, even when the foundational tools of their trade become scarce. The management of anesthesia drug shortages is, ultimately, a definitive test of a healthcare system's maturity, collaboration, and unwavering commitment to patient safety in the face of systemic failure.

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